King County
Washington State 2005
Climate Change Conference

October 27, 2005

Afternoon Hydropower Session

Exploring the Options

Combined Heat & Power

Presented by

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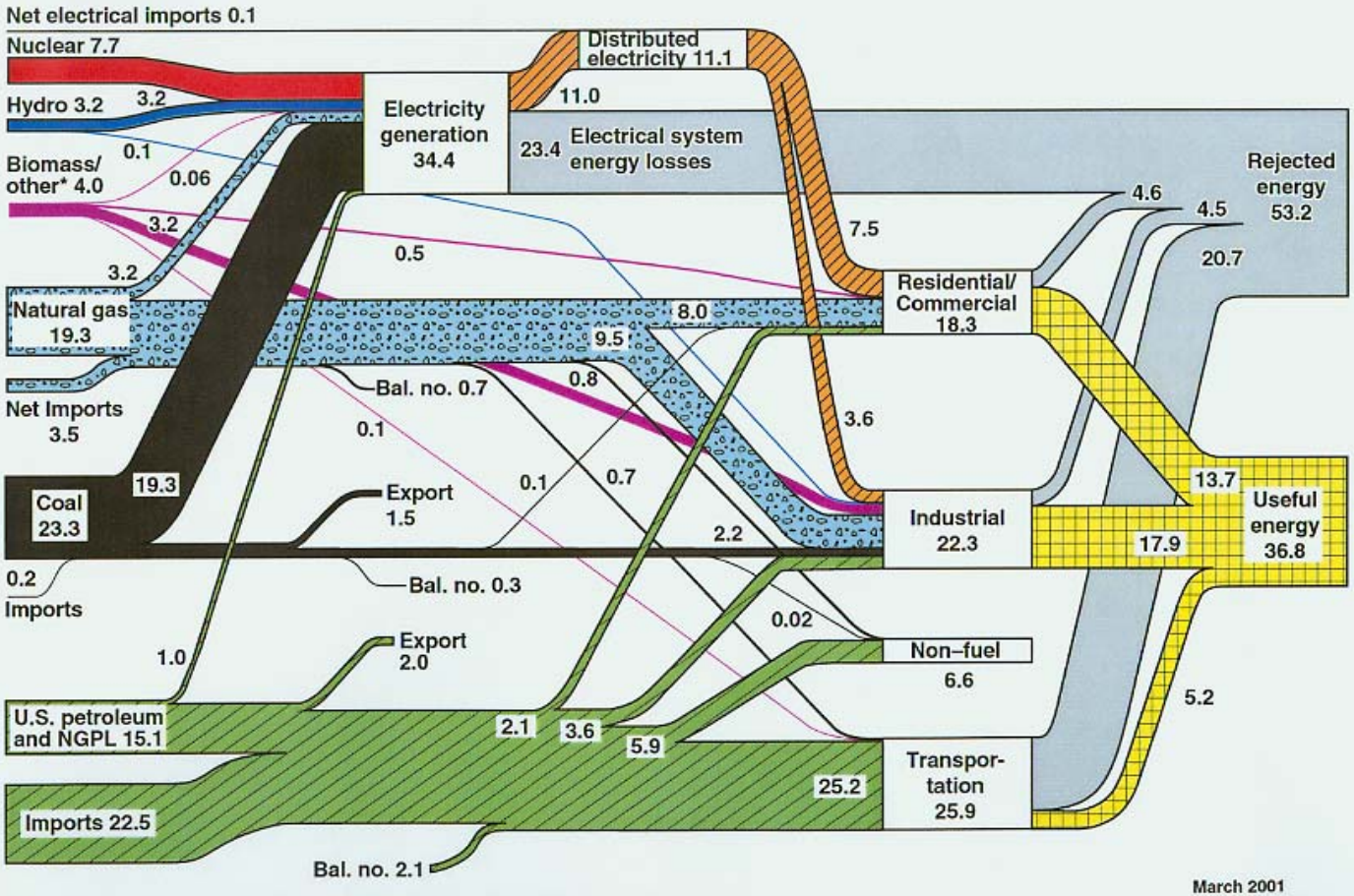
U.S. Energy Flow – 1999
Net Primary Resource Consumption 97 Quads



Source: Production and end-use data from Energy Information Administration, *Annual Energy Review 1999*
*Biomass/other includes wood and waste, geothermal, solar, and wind.

March 2001
Lawrence Livermore
National Laboratory

U.S. ENERGY USE & EFFICIENCY BY SECTOR

Energy Sector	Energy Input (a)	Useful Energy (a)	Percentage Useful Energy	Percentage Wasted Energy
Industry	22.3	17.9	80.3	19.7
Commercial/Residential	18.3	13.7	74.5	25.5
Electricity Generation	34.4	11.0	32.0	68.0
Transportation	25.9	5.2	20.0	80.0

(a) Energy expressed in Quads
(b) One Quad = 1 quadtrillion Btu = 10^{18} Btus

U.S. POWER GENERATION EFFICIENCY

Thermal power plants generate 91% of electricity

Average thermal efficiency ~ 32%

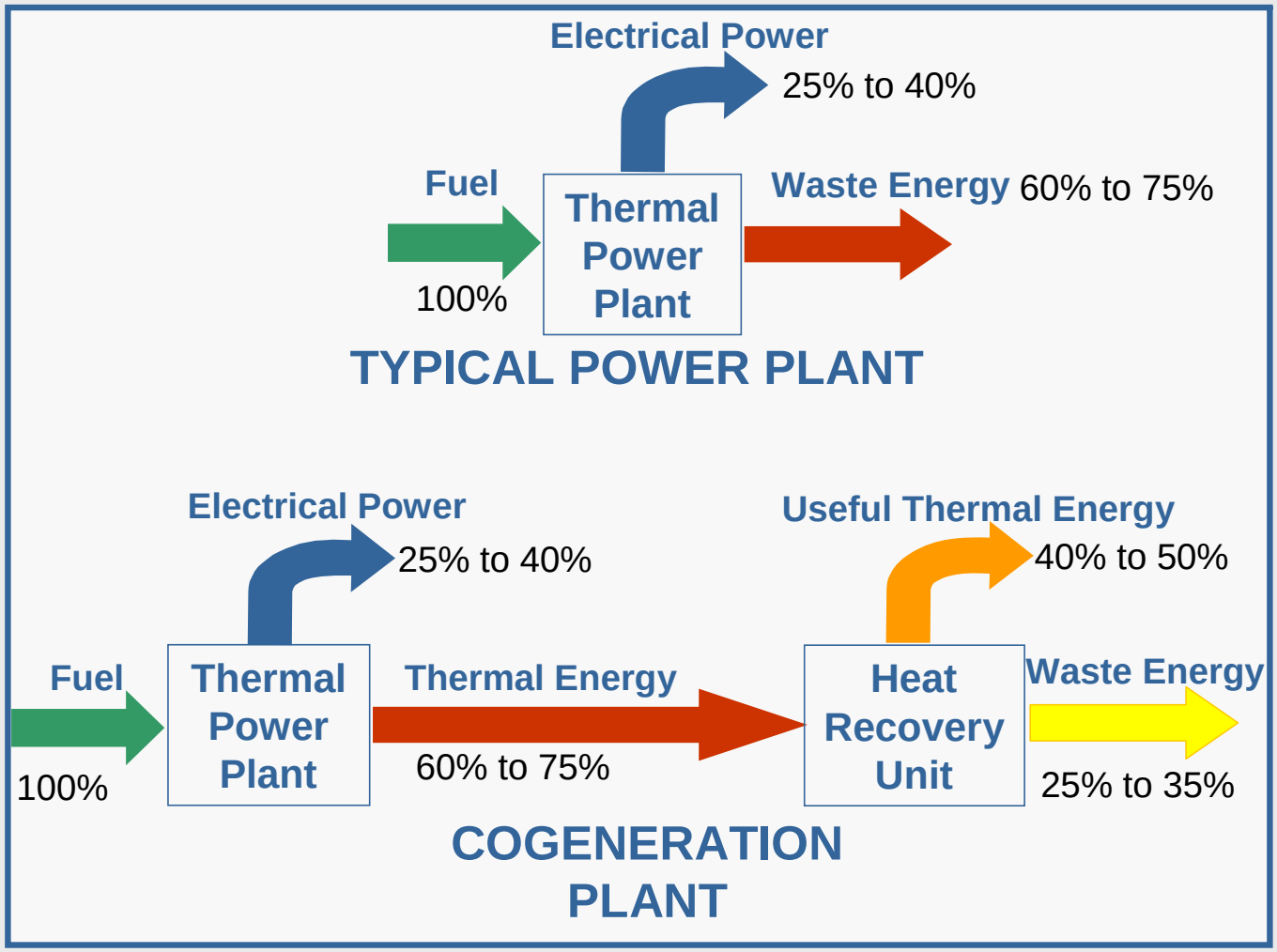
Average heat rate ~ 10,700 Btu/kWh

Combined-cycle heat rates ~ 7,000 Btu/kWh*

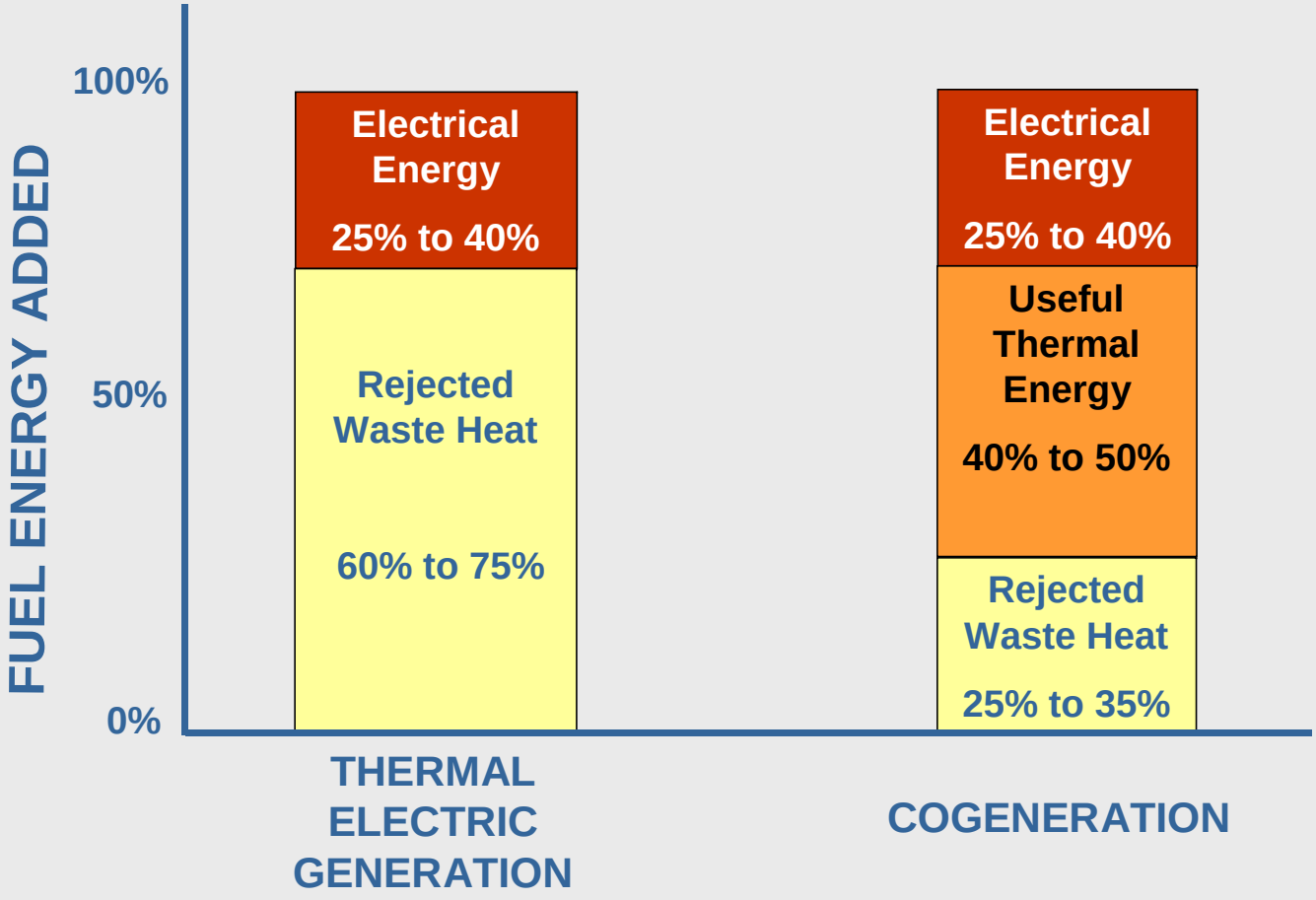
High efficiency CHP heat rate ~ 5,500 Btu/kWh*

Heat Recovery CHP ~ 0 Btu/kWh

*** Based on natural gas fuel higher heating value**

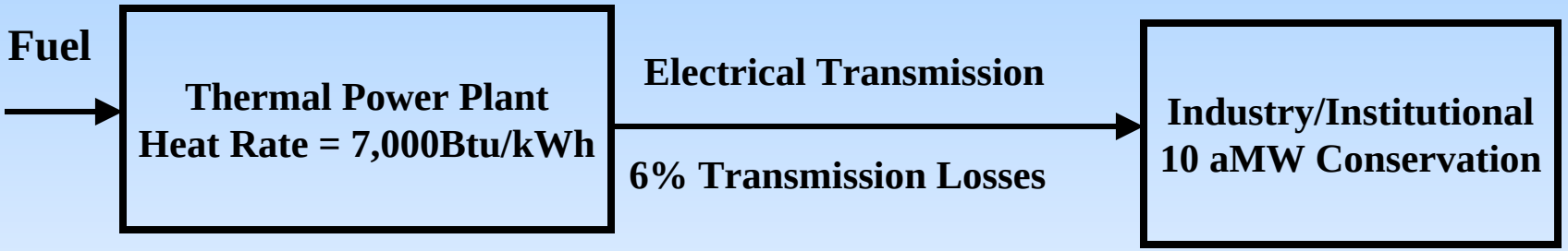

Electrical Power
25% to 40%
Fuel
Thermal Power Plant
Waste Energy 60% to 75%
100%
TYPICAL POWER PLANT
Electrical Power
25% to 40%
Useful Thermal Energy
40% to 50%
Fuel
Thermal Power Plant
Thermal Energy
Heat Recovery Unit
Waste Energy
100%
60% to 75%
25% to 35%
COGENERATION PLANT

COGENERATION vs THERMAL ELECTRIC GENERATION



Electric Power Savings

Case 1
10 aMW Electrical Conservation



Net Power Savings = 10.63 MW

Net Fuel Savings = 74.4 MMBtu/hr

NO_x Reduction = 2.87 Tons/year*

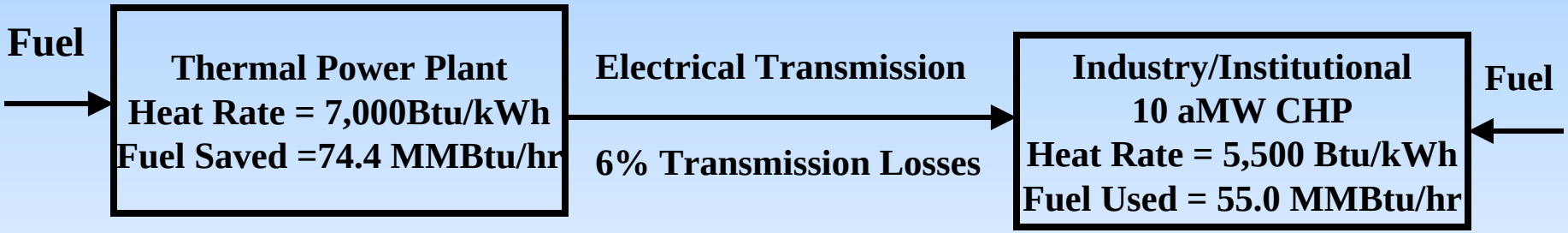
CO Reduction = 3.5 Tons/year*

CO_2 Reduction = 36,830 Tons/year

*** Based on NO_x and CO Emissions of 2.5 ppmv**

Electric Power Savings

Case 2
10 aMW CHP/Cogeneration



Net Power Savings = 10.63 MW

Net Fuel Savings = 19.4 MMBtu/hr

NO_x Reduction = 25.4 Tons/year*

CO Reduction =10.2 Tons/year*

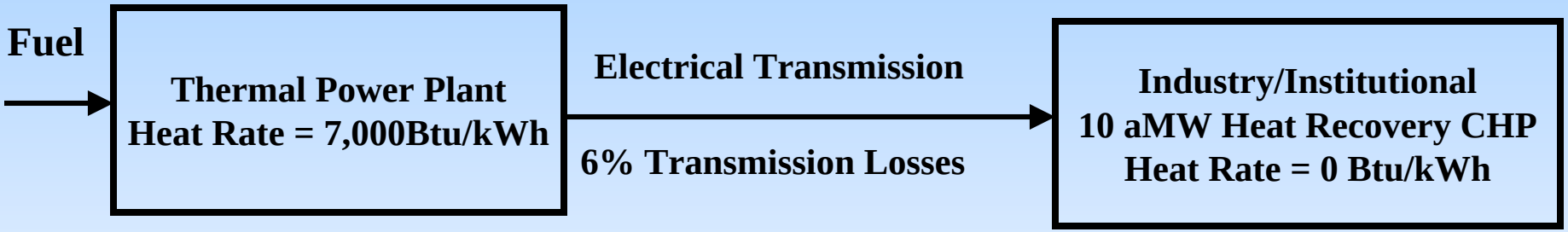
CO_2 Reduction = 8,973 Tons/year

*** Based on NO_x and CO Emissions of 2.5 ppmv and EPA boiler emission factors.**

Electric Power Savings

Case 3

10 aMW Heat Recovery CHP



Net Power Savings = 10.63 MW

Net Fuel Savings = 74.4 MMBtu/hr

NO_x Reduction = 2.87 Tons/year*

CO Reduction = 3.50 Tons/year*

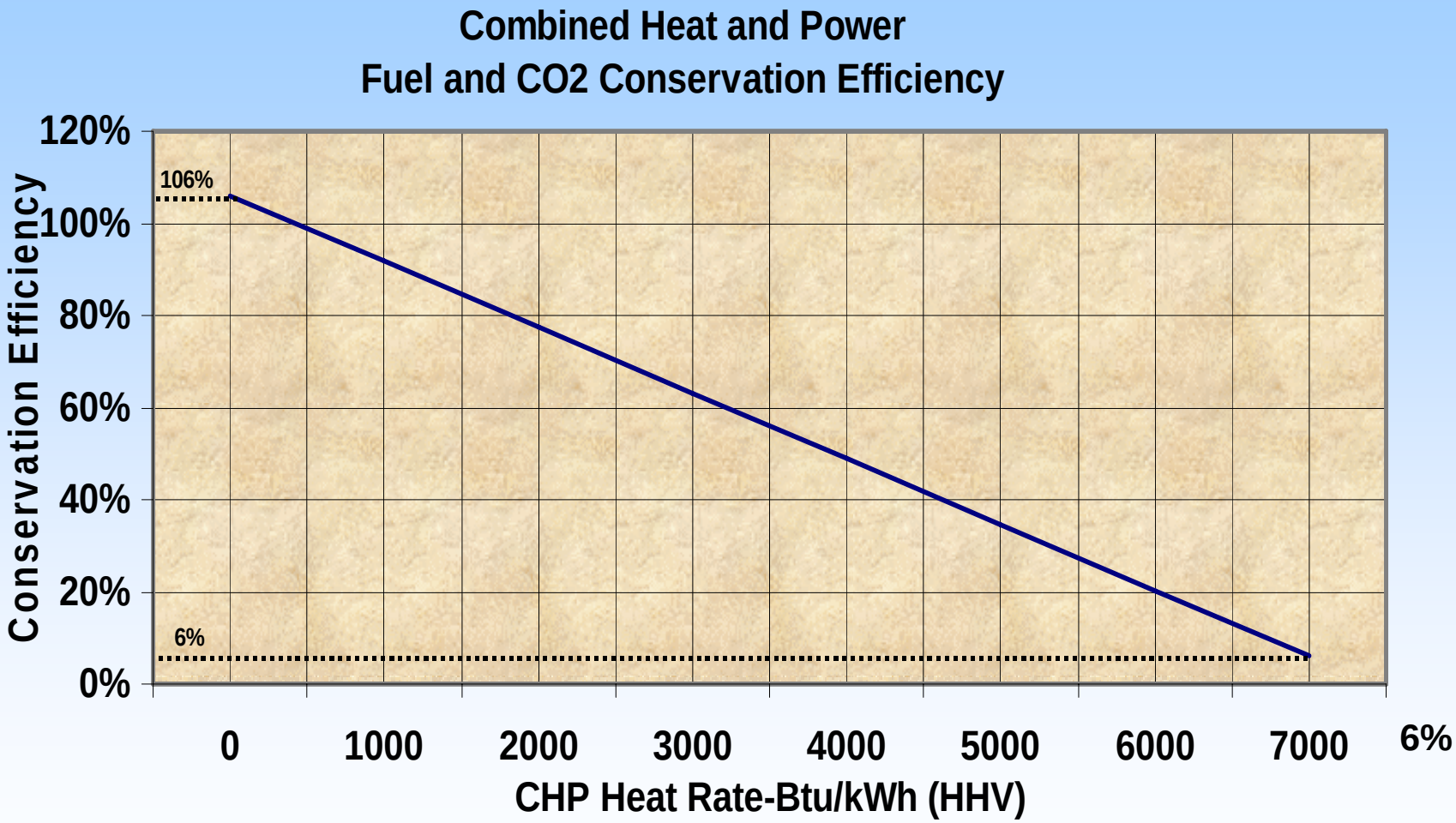
CO_2 Reduction = 36,830 Tons/year

*** Based on NO_x and CO Emissions of 2.5 ppmv**

Electric Power Savings Summary

	Case 1 10 aMW Conservation	Case 2 10 aMW High Efficiency CHP	Case 3 10 aMW Heat Recovery CHP
Power Savings	**10.63 MW**	**10.63 MW**	**10.63 MW**
Fuel Savings	**74.4 MMBtu/hr**	**19.4 MMBtu/hr**	**74.4 MMBtu/hr**
NO_X Reduction	**2.87 Tons/year***	**25.4 Tons/year***	**2.87 Tons/year***
CO Reduction	**3.5 Tons/year***	**10.2 Tons/year***	**3.50 Tons/year***
CO_2 Reduction	**36,830 Tons/year**	**8,973 Tons/year**	**36,830 Tons/year**

Case 1 - * Based on NO_X and CO Emissions of 2.5 ppmv
Case 2 - * Based on NO_X and CO Emissions of 2.5 ppmv and EPA boiler emission factors
Case 3 - * Based on NO_X and CO Emissions of 2.5 ppmv


Combined Heat and Power
Fuel and CO2 Conservation Efficiency
Conservation Efficiency
120%
100%
80%
60%
40%
20%
0%
106%
6%
0
1000
2000
3000
4000
5000
6000
7000
6%
CHP Heat Rate-Btu/kWh (HHV)

Emission Comparison
Combined Cycle and Combined Heat & Power Facilities

Emission	Combined Cycle FA Technology	Cogeneration LM 6000	Cogeneration Advantage
NO_x Emissions	574 lb/yr/MW	-4,499 lb/yr/MW Net Reduction	-5,073 lb/yr/MW A Net Emission Reduction
CO Emissions	701 lb/yr/MW	-1,338 lb/yr/MW Net Reduction	-2,039 lb/yr/MW Net Reduction
CO_2 Emissions	3,683 tons/yr/MW	2,790 tons/yr/MW	-893 Tons/yr/MW 24 %Less

CHP/Cogeneration Advantages

- **More Cost Effective**
  - **Delivered Power Cost 30% less**
- **More Energy Efficient Power**
  - **Requires 25% to 100% Less Fuel**
- **Lower Variable Costs**
- **Lower Air Emissions**
  - **Net Reduction of NO_x & CO Emissions**
  - **Reduced CO_2 Emissions**

Key CHP Obstacles

- **High Capital Cost**
- **High Investment Return Requirements**
- **Credit Issues**
- **Non-Alignment of Utility Interests**
- **High Standby Rates (Non-Cost Based)**
- **Low Avoided Cost Rates**
- **Limited Access to Wholesale Markets**

Solutions

- **Allow utilities to “Markup” purchased CHP power.**
- **Allow utilities to invest and rate base CHP.**
- **Cost-based standby/ancillary services.**
- **Avoided costs based on capital & energy costs of most recent utility owned plant.**

Solutions

- **Establish Energy Trust/Climate Trust to invest in energy conservation and greenhouse gas mitigation.**

- **State-backed financing for energy conservation/greenhouse gas mitigation.**